Effects of Different Glycaemic Index Foods and Dietary Fibre Intake on Glycaemic Control in Type 1 Diabetic Patients on Intensive Insulin Therapy

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To evaluate the influence of a low glycaemic index (GI), high GI and high fibre diet on glycaemic control and insulin requirement in Type 1 diabetic patients on intensive insulin therapy, nine well-controlled, highly-motivated Type 1 diabetic patients were put on a control diet for 12 days and then randomized in a consecutive manner to 12 days of each diet, in a crossover design. During each experimental diet, the study subjects adjusted their premeal insulin (soluble) dose to maintain their 1-h postprandial capillary glucose at or below 10 mmol l^{-1}. At the end of each experimental diet, they were submitted to a standardized breakfast of the diet under study, using the same premeal insulin dose as that required for the control diet. The control diet contained 16.0 ± 3.0 g of fibre day^{-1} with a GI of 77.4 ± 2.7 compared to 15.3 ± 6.3 and 66.2 ± 1.2 for the low GI diet, 17.1 ± 7.2 and 92.9 ± 3.6 for the high GI diet, and 56.1 ± 3.6 (including 15 g of guar) and 73.5 ± 2.1 for the high fibre diet. Prebreakfast capillary blood glucose (6.2 ± 1.2 mmol l^{-1}) on the low GI diet and postbreakfast capillary blood glucose (8.7 ± 1.8 mmol l^{-1}) on the high fibre diet were significantly lower than the values obtained with the control diet (8.0 ± 1.8 and 10.6 ± 2.4, respectively; $p < 0.05$). No change in premeal or basal insulin dose was required. During the standardized breakfasts, the incremental area under the curve was 1.6 ± 1.5 mmol l^{-1} min^{-1} for the control diet compared to 1.1 ± 1.8 for the low GI diet, 3.2 ± 1.4 for the high GI diet ($p < 0.05$ versus low GI and high fibre; $p = 0.08$ versus control), and 1.0 ± 0.9 for the high fibre diet. These observations indicate that in well-controlled Type 1 diabetic subjects on intensive insulin therapy, major alterations in the GI and fibre content of meals induce small but significant changes in glucose profile. In everyday life, however, these differences are blunted, and plasma glucose remains within the target range for optimal metabolic control.

Diabet. Med. **15: 972–978 (1998)**

KEY WORDS **glycaemic index; dietary fibre; diet; Type 1 diabetes mellitus; intensive insulin therapy; insulin requirement**

Received 8 August 1997; revised 17 April 1998; accepted 26 June 1998

Introduction

Diet has been recognized as the cornerstone of therapy for diabetes mellitus ever since the disease was first identified. In the early 1980s, two major dietary concepts stimulated interest in the nutritional approach to control the postprandial glycaemic rise in diabetes: the glycaemic index (GI) and dietary fibre. Crapo *et al.*[1,2] were the first to report that different carbohydrates have different effects on postprandial blood glucose. In 1981, these observations generated the concept of the GI index, describing this property for various GI foods.[3,4] It was hoped that this index would provide a means of predicting the impact of individual carbohydrate-containing foods on the postprandial glucose and help in the selection of foods for diabetic diets. Most medium and long-term studies comparing high and low GIs reported a desireable effect of low GI diet on glycaemic control.[4–9] However, the practical significance for people with diabetes remains controversial.[10] The theory has never, to to our knowledge, been tested in well-controlled Type 1 diabetic patients.

Viscous dietary fibre, shown to flatten the postprandial glycaemic profile in healthy volunteers, has been proposed as a potentially useful adjunct in the treatment of diabetes[11] and many studies have confirmed its role in reducing postprandial blood glucose[12–15] and insulin levels.[15,16] The efficacy of high fibre diets in the treatment of diabetes remains, controversial,[17–19] and, the use of purified fibre as a supplement is not advocated.[20]

Sponsors: Medical Research Council of Canada.
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 CCC 0742–3071/98/110972–07$17.50

The present study was designed to assess the effect of a low GI diet, a high GI diet and a high fibre diet on glycaemic control and on premeal insulin requirement in well-controlled Type 1 diabetic patients on intensive insulin therapy.

Research Design and Methods

Nine patients (2 females and 7 males) with Type 1 diabetes (lack of C-peptide response to a standard meal) participated in the study. They had been on intensive insulin therapy for at least 3 months with either multiple subcutaneous insulin injections of beef-pork Ultralente (UL) as basal insulin, and human Soluble (Sol) insulin premeal boluses ($n = 5$) or continuous subcutaneous insulin infusion (CSII) with multiple basal rates and premeal boluses ($n = 4$). All subjects were accustomed to calculating their premeal insulin dose according to the carbohydrate content of the meal, as described.[21] They had near-normal haemoglobin A_{1c} (HbA_{1c}) (5.8 ± 0.2 %; non-diabetic = 3.5–5.7 %). Gastroparesis was excluded in all patients by gastric emptying analysis using digestible solid food labelled with 99 mTc.[22] The study was approved by the institutional ethics committee and all participating subjects gave their signed informed consent.

Each subject's dietary habits, energy intake and carbohydrate counting were recorded at the time of consumption in a 3-day dietary diary for 1 weekend day and 2 weekdays. For each experimental diet, the subjects were advised to maintain their usual energy intake and distribution: 50–55 % as carbohydrate, 15–20 % as proteins and 25–30 % as lipids. They were counselled on keeping dietary records, but had no instruction on the GI or fibre content of food. Each diet was followed for 12 days. All patients began with the control diet (intermediate GI and low fibre intake) and were then randomized consecutively without washout, to the high GI, low GI and high fibre diets. The validity of 3-day dietary records for dietary intervention studies has been demonstrated.[23–25]

Four lists of food items were provided: Group A corresponded to low GI (<60); Group B to intermediate GI (60–90); Group C to high GI foods (>90); Group D to high fibre food choices. For the control diet, the patients were asked to select their carbohydrates equally among Groups A, B and C; for the low GI diet, they were asked to select two-thirds of their carbohydrates from Group A and for the high GI diet, two-thirds from Group C. For the high and low GI diets, the last one-third of carbohydrates had to be chosen equally between the two remaining groups of GI food items. For the high fibre diet, the patients were instructed to increase their intake of high fibre food choices listed in Group D to ensure a daily intake of at least 40 g while maintaining an intermediate GI. At least 15 g were consumed as soluble fibre in guar-containing biscuits (5 g per biscuit), eaten with each meal. Each biscuit, made with oatmeal, seedless raisins, chocolate chips, condensed milk, margarine and 5 g of guar, contained 317.4 kJ (76 kcal) distributed as follows: 51 % carbohydrate, 42 % fat, and 7 % protein.

To allow for comparison between the GI diets without the confounding effect of fibre content, similar fibre intake was maintained for the high and low GI diets as well as for the control diet (intermediate GI). Thus, Group A contained a higher proportion of fruit and dairy products than Group C, which contained predominantly starchy foods. Fruits included in Group A had a GI below 60.[26]

The test subjects adjusted their insulin doses to maintain premeal capillary blood glucose between 4 and 7 mmol l^{-1} and 1-h postprandial capillary blood glucose below 10 mmol l^{-1}. During the last week of each experimental diet, they completed a 3-day dietary diary listing all food items ingested, portion size, carbohydrate content, premeal insulin dose (Reg) and basal insulin dose (UL or Reg for CSII) as well as capillary blood glucose before and 1 h after each meal.

At the end of each diet, all subjects were given a standardized breakfast for the diet under study (Table 1). It was eaten at 7:30 am with the same premeal dose of soluble insulin per g of carbohydrates as the one required for the standardized breakfast of the control diet. Meals were consumed over a 15-min period, and blood samples were drawn at time 0, 30, 60, 120, 180, 240 and 300 min to measure plasma glucose and free plasma insulin concentrations.

Capillary blood glucose was measured by patients with a memory glucose reflectance meter (kindly provided by Bayer Inc., Etobicoke, Ontario). Only values recorded in their nutritional diary for 3 representative days of each period were used for statistical analysis. Values were verified against the memory of the reflectance meter. During the standardized meal, blood samples were deproteinized with 6 % perchloric acid, and plasma glucose was measured by the hexokinase method.[27] Plasma free insulin levels were quantitated by ^{125}I-insulin radioimmunoassay (Immunocorp, Montréal, Québec, Canada), using a double antibody technique after extraction by polyethylene glycol precipitation.[28] Glycosylated haemoglobin was measured by fast protein liquid chromatography[29] at the beginning and end of the study. Fructosamine levels were assessed at the end of each experimental diet by colorimetric reaction to nitroblue tetrazolium (fructosamine test, Roche, Nutley, New Jersey, USA) (non-diabetic = 2.0 to 2.7 mmol l^{-1}).[30]

Dietary data were analysed for carbohydrates, proteins, lipids, fibres, and GI, using 'Nutritionist 3' computer software (N-Squared Computing, Salem, Oregon, USA) and the Miles database as modified by Thomas M.S. Wolever (1988, personal communication). These modifications were based on the Condensed Canadian Nutrient File[31] which was updated for carbohydrates and fibres according to the manufacturers' information[32] and by estimation of some unlisted food items. The GI values using white bread as a reference were included in the Miles database based on published data where possible [33] and on estimation for other food items by Wolever.

Table 1. Standardized breakfast for each experimental diet

	Control diet	Low GI diet	High GI diet	High fibre diet
Total kJ (KCAL)	1820 (435)	1718 (411)	1820 (435)	1916 (456.2)
Distribution (%)				
Carbohydrates	57.1	57.7	58.4	60.5
Lipids	30.6	27.0	27.5	26.4
Proteins	12.3	15.3	14.1	13.1
Fibres (g)	4.5	2.1	4.1	22.3
Glycaemic index (GI)				
Mean GI	73.3	62.5	98.5	75.1
Distribution/GI food groups (%)				
Low	34.9	72.4	16.0	36.9
Intermediate	34.7	13.4	18.6	31.2
High	30.4	14.2	65.4	31.9
5-h IAUC for glycaemic profile (mmol l^{-1}) ± SD	1.6 ± 1.5	1.1 ± 1.8	$3.2 \pm 1.4^{a,b,c}$	1.0 ± 0.9

[a] $p = 0.02$ versus low GI diet; [b] $p = 0.05$ versus high fibre diet; [c] $p = 0.06$ versus control diet.

The sample size required to ensure a power of 0.8 for detecting a difference of at least 1.5 mmol l^{-1} on postprandial glycaemic values when using a 2-sided hypothesis test with a level of 0.05 was:[34]

$$n = 2\left[\frac{1.96 + 0.84}{1.5}\right]^2 (1-\rho)^2 = 6$$

where ρ was the correlation (assumed to be 0.1) and where the standard deviation was estimated at 1.0 based on a previous study.[33] A change in postprandial blood glucose of 1.5 mmol l^{-1} was considered to be clinically meaningful in the context of intensive insulin therapy.

Statistical analysis of the four dietary interventions was performed with Friedman's repeated measures analysis of variance on ranks and comparisons made between groups by pairwise multiple comparison procedures (Tukey test).

Results

The mean duration of diabetes was 15 ± 7.5 years. Control was excellent (HbA_{1c}: 5.8 ± 0.6 %, fructosamine 2.9 ± 0.3 mmol l^{-1}). Body mass index was slightly high (27.1 ± 1.4 kg m^{-2} in 2 subjects. The results obtained with these 2 subjects were similar to those of the non-obese subjects and they were included in the analysis. There was no difference between patients treated with multiple subcutaneous injections ($n = 5$) or CSII ($n = 4$).

For the experimental diets, values contained in the 3-day dietary diary were used for statistical analysis. Reported consumption was very close to the prescribed intake, although patients did not know how to calculate calories, fibre content or GI.

The diets were identical for energy intake and distribution of carbohydrates, lipids and proteins (Table 2). The prescribed distribution closely followed for the 3 daily meals with the exception of a slightly but significantly lower carbohydrate intake for dinner on the high GI diet (45.5 %; $p = 0.01$). No effect of the sequence of the different diets was found.

Using the Miles computerized database, the GI value of the control diet was 77.4 ± 2.7 compared to 66.2 ± 1.2 ($p = 0.001$) for the low GI diet, 92.9 ± 3.6 ($p = 0.001$) for the high GI diet and 73.5 ± 2.1 for the high fibre diet (Table 2). These GI values were very similar for breakfast, lunch and dinner for each experimental diet. The proportion of food coming from the different groups of GI food list was close to the prescription (Table 2). To maintain a constant fibre intake between the low and high GI diets, the percentage of carbohydrate from starch was lower in the low GI diet (19.6 %) than in the high GI (32.5 %) or control diet (28.7 %) ($p = 0.05$). Mean fibre intake was significantly higher in the high fibre diet (56.1 g day^{-1}) than in other diets (16.1 g day^{-1}; $p = 0.0001$; Table 2). For the high fibre diet, approximately 50 % of fibre were ingested with breakfast, the rest being equally divided between lunch and dinner, with at least 5 g of soluble fibre for each meal.

During the four experimental diets, all capillary blood glucose concentrations were comparable with the exception of a lower 1-h postprandial value on the high fibre diet for breakfast (8.7 ± 1.8 $mmol^{-1}$), compared to the control diet (10.6 ± 2.4 mmol l^{-1}; $p = 0.05$) and a lower prebreakfast value on the low GI diet (6.2 ± 1.2 mmol l^{-1}) compared to the control diet (8.0 ± 1.8 mmol l^{-1}; $p < 0.05$; Table 3). Fructosamine was not significantly different after each diet: 2.9 ± 0.3 control; 2.9 ± 0.6 low GI; 3.1 ± 0.3 high GI and 3.0 ± 0.3 high fibre. HbA_{1c} was comparable at the beginning (5.8 ± 0.6 %) and end of the study (5.4 ± 0.6 %). The reported and documented incidence of minor hypoglycaemia (< 4.0 mmol l^{-1}) was 3.2 ± 0.24 control; 4.3 ± 1.3 low GI; 4.0 ± 2.8 high GI diet; 2.7 ± 2.8 high fibre. No severe hypoglycaemia was reported. Neither basal insulin requirements (UL or the

Table 2. Energy distribution and glycaemic index for each experimental diet based on a 3-day dietary diary

	Experimental diets			
	Control	Low GI	High GI	High fibre
kJ day^{-1} (kcal day^{-1})	8333 ± 1531 (1994 ± 378)	7762 ± 1419[c] (1857 ± 339)	7704 ± 1782 (1843 ± 426)	8476 ± 2100 (2025 ± 580)
kJ distribution (%) and fibres (g) per day				
Carbohydrates	53.2 ± 4.8	56.9 ± 3.9	52.6 ± 5.7	55.7 ± 4.2
Lipids	27.8 ± 5.7	25.8 ± 4.2	28.5 ± 7.2	27.3 ± 4.8
Proteins	18.2 ± 0.21	17.2 ± 2.1	18.0 ± 2.4	17.0 ± 1.5
Fibres	16.0 ± 3.0	15.3 ± 6.3	17.1 ± 7.2	56.1 ± 3.6[b]
Glycaemic index day^{-1}	77.4 ± 2.7	66.2 ± 1.2[a]	92.9 ± 3.6[a]	73.5 ± 2.1
Glycaemic index meal^{-1}				
Breakfast	75.0 ± 2.7	64.5 ± 0.9[a]	91.2 ± 4.2[a]	73.2 ± 1.2[a]
Lunch	77.3 ± 2.7	67.3 ± 2.7[a]	92.7 ± 5.4[a]	72.2 ± 2.4
Dinner	80.1 ± 9.5	66.7 ± 2.4[a]	94.8 ± 4.2[a]	73.3 ± 2.4
Glycaemic index distribution according to GI food groups/day (%)				
Low GI	31.5 ± 1.2	68.9 ± 2.7	17.1 ± 6.9[a]	36.3 ± 2.7
Intermediate GI	34.8 ± 3.6	11.8 ± 2.7[a]	10.1 ± 8.1[b]	32.8 ± 5.2
High GI	33.6 ± 3.6	19.3 ± 3.3[c]	72.1 ± 3.9[c]	30.9 ± 2.4

Means ± SD (n = 9).
[a] $p = 0.01$ compared to the control diet; [b] $p = 0.0001$ compared to the control diet; [c] $p = 0.05$ compared to the control diet.

Table 3. Capillary blood glucose and insulin requirements for each experimental diet

Control diet	Low GI diet	High GI diet	High fibre diet
Capillary blood glucose (preprandial/1 h postprandial)			
Breakfast			
8.0 ± 1.8/10.6 ± 2.4	6.2 ± 1.2[a]/9.4 ± 2.4	6.8 ± 1.5/10.7 ± 4.2	7.7 ± 0.6/8.7 ± 1.8[a]
Lunch			
5.5 ± 2.1/7.2 ± 1.5	4.4 ± 1.5/6.3 ± 2.1	4.9 ± 2.4/7.9 ± 4.2	5.5 ± 2.4/7.2 ± 1.8
Supper			
5.3 ± 2.1/8.0 ± 2.4	4.7 ± 1.2/8.0 ± 1.5	5.5 ± 2.1/7.5 ± 2.4	6.1 ± 1.5/7.5 ± 0.45
Total insulin dose (U 24 h^{-1})			
57.2 ± 13.7	57.8 ± 14.2	58.1 ± 12.5	56.5 ± 12.4
Basal insulin requirement (U 24 h^{-1})			
24.8 ± 5.2	24.7 ± 5.3	26.1 ± 5.4	25.3 ± 5.2
Preprandial insulin requirement (Ug^{-1} CHO)			
Breakfast			
0.18 ± 0.15	0.18 ± 0.15	0.20 ± 0.15	0.19 ± 0.06
Lunch			
0.12 ± 0.09	0.10 ± 0.06	0.12 ± 0.06	0.09 ± 0.06
Dinner			
0.11 ± 0.06	0.11 ± 0.06	0.13 ± 0.06	0.11 ± 0.06

Data expressed as means ± SD.
[a] $p < 0.05$ versus control diet.

basal rate for CSII) nor premeal soluble insulin doses were affected by the different diets (Table 3). Mean body weight remained stable throughout.

Mean fasting plasma glucose before the standardized breakfast for the control diet was 6.2 ± 1.8 mmol l^{-1} and was not significantly different for the other experimental standardized breakfasts (Figure 1a). The high GI breakfast gave a higher and the low GI and high fibre diet a lower glycaemic profile compared to the control diet (Figure 1(a)). The incremental area under the curve (IAUC) for the high GI diet was significantly higher (3.2 ± 1.4 mmol l^{-1}) than for the low GI (1.1 ± 1.8 mmol l^{-1}; $p = 0.02$) and

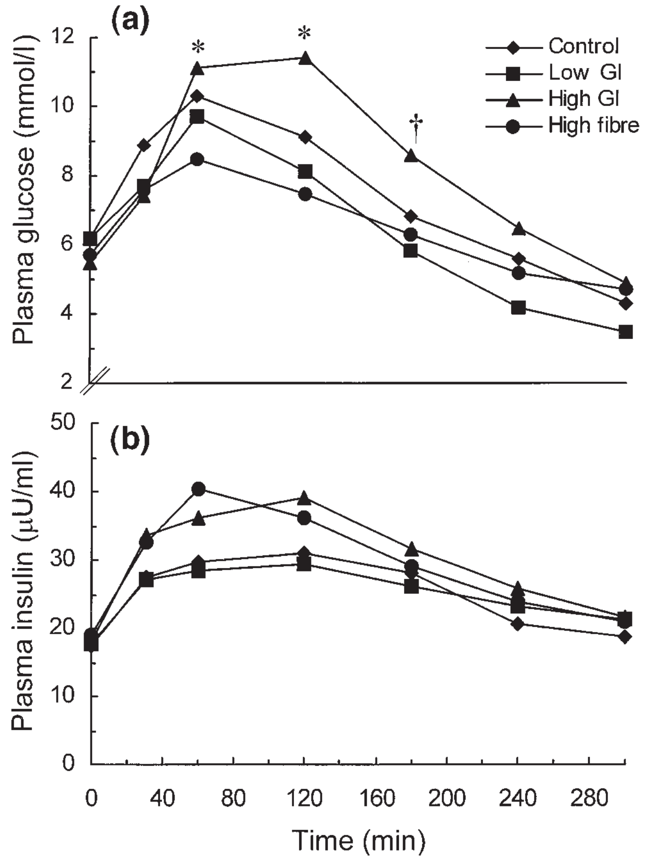

Figure 1. (a) Mean plasma glucose and (b) mean free plasma insulin profiles in response to a standardized breakfast for the control, low GI, high GI, and high fibre diets in insulin-dependent diabetic subjects (n = 9). * $p < 0.05$ high GI diet versus high fibre diet; † $p < 0.02$ high GI diet versus low GI diet

high fibre (1.0 ± 0.9 mmol l^{-1}; $p < 0.05$) diets with a non-significant trend when compared with the control diet (1.6 ± 1.5 mmol l^{-1}; $p = 0.06$). This held for analyses done over 3 or 5 h or with the total area under the curve (AUC) or IAUC. The free plasma insulin profile in response to subcutaneous premeal soluble insulin was not significantly different between the four experimental standardized breakfasts (Figure 1(b)).

Discussion

We set out to assess the effects of low and high GI diets and increased dietary fibre as part of mixed meals on glycaemic control and insulin requirement in patients with well-controlled Type 1 diabetes mellitus on intensive insulin therapy. During standardized breakfasts, on a fixed insulin dose, the glucose profile was higher for the high GI diet compared to the low GI and high fibre diets. However, on a day to day basis, alterations in the GI did not induce any clinically significant change in glycaemia assessed by home capillary blood glucose measurements. Only the high fibre experimental diet produced a small but significant decrease in postbreakfast capillary blood glucose. Not even this necessitated any modification of premeal or basal insulin requirement.

The usefulness of the GI and fibre content of food to predict the glycaemic response to a mixed meal is controversial.[9,10,35–38] The apparent discrepancies may be due to a number of factors including: compliance to the prescribed diets; food composition, processing and preparation; uncontrolled biases, such as non-controlled fibre content between the low and high GI diets (higher fibre content in the low GI diet than in the high GI diet); type of diabetes and its control; the duration of time over which data are collected and analysed; the use of postprandial blood glucose concentrations versus IAUC in the assessment of final conclusions;[39–41] and the accuracy and frequency of postprandial glucose measurements.

The three-day food records indicated that the prescribed diets were closely followed (Table 2). Furthermore, since each subject served as his or her own control, it was assumed that food composition, processing and preparation were similar between the experimental diets. The GI values for the diets are very similar to those used by Weyman-Daum *et al.*,[42] but different from other interventions.[37,43,44] However, when considered in units of variation, the divergence between our high and low GI diets (~27 units) was in the upper range of variation considered to be efficient (~15 units).[45] We arbitrarily set the range of our low, intermediate and high GI food groups at < 60, 60–90 and > 90, so that the carbohydrate-containing foods most commonly eaten could be distributed among these three groups, encouraging compliance. The fact that our subjects could not calculate their own GI lends credibility to the GI estimated from the dietary journal. The mean dietary fibre intake for the control, low GI, and high GI diets (16 g day^{-1}) is consistent with the average amount of fibre normally ingested by the North American population.[20] The high fibre diet delivered 56.1 g of fibre per day (including at least 15 g of soluble fibre), well above the 40 g that used to be recommended by the American Diabetes Association.[20] Most investigators comparing different GI diets have not controlled for different fibre content of their GI diets. In the present study, care was taken to have comparable fibre content in the medium, low, and high GI diets (Table 2). The high GI and control diets contained a higher proportion of starchy carbohydrate (~30 %) than the low GI diet (~20 %), where a higher proportion of carbohydrate came from fruits and dairy products. This does not invalidate our results because the GI is defined by a glycaemic response and the major mechanism by which the low GI is obtained for starchy foods (slower carbohydrate absorption) is in large part shared by fruits (slow facilitated diffusion through enterocytes for fructose) and dairy products (slow rate of hydrolysis by lactase to convert lactose to its simple sugar component).[46,47]

For Type 1 diabetic patients treated with multiple insulin injections, the combination of carbohydrate counting and specific algorithms for adjusting insulin per gram of CHO offers greater flexibility in choosing foods, portion size, timing of meals and physical activity.[48,49] In the intensively treated group of the DCCT,

carbohydrate counting resulted in a further 0.56 % reduction of HbA_{1c}.[50] In our study, all subjects were on tight glycaemic control at the beginning of the study. This was well maintained throughout the study, as shown by capillary blood glucose concentrations and fructosamine levels. Weyman-Daum *et al.*[42] investigated the effects of high GI, low GI, and high fibre breakfasts on postprandial hyperglycaemia in poorly controlled Type 1 subjects and could not show any effect on postprandial glycaemic profiles between the three test breakfasts, despite insulin dose adjustment, perhaps because the preprandial glucose level affects the glycaemic response to a meal.[40]

Mean premeal and basal insulin requirements were not affected by large variations in the GI or fibre content of the diet. We have already shown that basal and premeal insulin (U $10\,g^{-1}$ carbohydrate) requirements are not affected by the amount of carbohydrate over a wide range in the diet (unpublished data from J.-L. Chiasson). The low GI and high fibre diets did not increase the incidence of hypoglycaemia. With the high fibre diet, the incidence of hypoglycaemia tended to decrease, probably due to the delayed absorption of carbohydrates. These data suggest that on a day to day basis, variations in the GI and fibre content of mixed meals do not require significant insulin adjustment to maintain normoglycaemia in well-controlled Type 1 diabetic patients on intensive insulin therapy who calculate their premeal insulin requirements based on the carbohydrate content of their meals.

In contrast to the outpatient data, where the only significant difference was a lower breakfast postprandial glycaemic value under the high fibre diet, the standardized breakfasts showed significant differences in the postprandial glycaemic profile. The single 1 h postprandial capillary blood glucose measurement used in outpatients is a crude reflection of the entire postprandial period, albeit the single best time-point to detect differences (see Figure 1(a)) The significant reduction of postprandial blood glucose after breakfast on the high fibre diet is consistent with results reported by others[43,44,51] and is probably explained by the fact that 50 % of daily fibre intake (28.8 g) was taken during this meal. Other studies have shown that delaying and prolonging carbohydrate absorption may have metabolic advantages in diabetes.[52] Similar investigations where the GI was reduced without changing the ratio of starch to sugars have achieved similar results.[4–8,53] The latter studies, however, also included an increase in dietary fibre.

In summary, in well-controlled Type 1 diabetes, standardized meals of a high GI are associated with higher postprandial glycaemic profiles compared to standardized low GI and high fibre meals. However, such GI variations do not necessitate any adjustment of basal insulin doses or of premeal soluble insulin dose in free-living patients. Likewise, while an increase of dietary fibre can decrease the postprandial rise in plasma glucose, and a low GI diet can reduce fasting plasma glucose, they are not sufficient to require adjustment of insulin doses. Type 1 diabetic patients on intensive insulin therapy can therefore incorporate low GI food and/or dietary fibre in their diet without any modification of algorithms for insulin adjustment to maintain normoglycaemia and without any increased risk of severe hypoglycaemia, and can safely use the carbohydrate content of their meals alone to calculate their insulin requirements and maintain good glycaemic control.

Acknowledgements

We thank T.M.S. Wolever for help in calculation of the glycaemic index and for advice in writing this article. We also acknowledge the expertise of E. Rahme who did the power calculations and statistical analysis. We are grateful to S. Bordeleau-Chénier for preparing the manuscript and illustrations and O. Da Silva for his editorial assistance. This study was supported by grants from the Medical Research Council of Canada. L. Lafrance is the recipient of a studentship from Fonds de la recherche en santé du Québec (FRSQ).

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